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# Central vs. Back Vowels

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*A brief survey of the phonological literature reveals that at least fourteen languages contrast a central and a back vowel which are otherwise identical (in height, rounding, tenseness, etc.). The classical binary feature [± back] is too weak to encode these distinctions. Furthermore, central and back vowels often pattern together as a natural class, while front and central vowels rarely do. Three previous feature systems are reviewed and argued to be inadequate for capturing these contrasts. Consequently, a new model is proposed which accounts for the empirical facts in a more insightful way. Specifically, the innovation involves redefining the feature [± back] (as a dependent of the Dorsal Node) so that it can distinguish between central and back vowels.*

## 1. Introduction

A small number of languages exhibit a minimal opposition between a central and back vowel which are equivalent in all other respects. For example, the vowel inventory of Nimboran includes the phonemes /ɨ/ and /ɯ/, where /ɨ/ is high, central, tense, and unrounded, while /ɯ/ is high, back, tense, and unrounded (Anceaux 1965).[1] A contrast between /ɨ/ and /ɯ/ is exceedingly rare in the languages of the world; Nimboran is the only case of the 451 languages in the UCLA Phonological Segment Inventory Database (Maddieson and Precoda 1992; hereafter UPSID) which contains both of these segments (more discussion of this point will be given in §2). An obvious and important question is, how can the phonological distinction between these two vowels (and others like them) best be encoded in our formal system of distinctive features? The SPE model (Chomsky and Halle 1968) employs the single binary feature [±back]. This is true also of most subsequent theories which follow the generative tradition, including more recent proposals in terms of hierarchical feature geometry trees (e.g. Clements 1985, Sagey 1986, McCarthy 1988, Odden 1991, and Halle 1995). None of these frameworks can distinguish between central and back vowels which are otherwise identical. There are at least two feature systems proposed in the literature which can capture the contrast between /ɨ/ and /ɯ/, but they are problematic in a number of respects. The goals of this paper are twofold: first I document a substantial body of evidence which demonstrates that central vs. back vowel contrasts must be formally dealt with as an authentic phonological phenomenon. Having done that, I then consider the implications of this fact for distinctive feature theory.

The remainder of this paper is organized as follows. In §2 I exhaustively review all of the languages known to me which distinguish central and back vowels. In §3 I consider earlier proposals which can handle such contrasts, and argue that they are inadequate. Consequently, in §4 I propose a new model which differs in a minimal yet significant way from other approaches and argue that it is superior. I conclude in §5 with a summary of my findings and a brief discussion of their theoretical significance.

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[1] The vowel system of Nimboran will be discussed more completely in §2.


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## 2. Further evidence for the contrast between central and back vowels

Since the earliest years of the classical generative period it has been recognized that central and back vowels often group together as a natural class in opposition to front vowels. Chomsky and Halle (1968) directly capture this dependency in their definition of the feature [±back]: "Back sounds are produced by retracting the body of the tongue from the neutral position; nonback sounds are produced without such a retraction from the neutral position" (p. 305). In the SPE model this "neutral position" is correlated with a tongue and jaw configuration approximating that of the vowel /ɛ/. Thus front vowels are classified as [–back] while both central and back vowel series are [+back]. Phonological evidence supporting this binary split is not difficult to produce. For example, a rule of Turkish vowel harmony groups /a o u ɨ/ as a natural class vs. the front vowels /i e ü ö/ (Kenstowicz 1994, Hony 1957):

| (1) | *noun* | *plural* | *gloss* |
|---|---|---|---|
| a. | dal | dal-lar | *branch* |
| b. | kol | kol-lar | *arm* |
| c. | kɨz | kɨz-lar | *daughter* |
| d. | kul | kul-lar | *slave* |
| e. | jel | jel-ler | *wind* |
| f. | göl | göl-ler | *sea* |
| g. | diš | diš-ler | *tooth* |
| h. | gül | gül-ler | *rose* |

In the Turkish data above the plural suffix is realized as [-lar] when the root contains either a central or a back vowel, and as [-ler] following a front vowel. Regardless of how we ultimately decide to encode the phonemic distinction between vowels such as /ɨ/ and /ɯ/, we must not lose sight of this fact; any explanatorily-adequate model must be able to capture the insight that central and back vowels often pattern together, and it should be able to do so in as simple and natural a way as the classical feature [+back] does.

A second point relevant to this discussion is the fact that in the vast majority of the world's languages, phonemic vowel systems do not contrast central and back vowels which are otherwise identical. It is for reasons such as these that Kenstowicz (1994:26) comments (with respect to the SPE model), "Most generative phonologists have eschewed introducing a distinct central category in addition to front and back; they have attempted to accommodate these vowels in other ways." For example, in Turkish the central vowels /ɨ a/ are [–round], while the back vowels /u o/ are [+round]. Thus Kenstowicz suggests that in most cases phonetically back vowels can be specified as [+back] while central vowels can simply be left unspecified for [back] in underlying forms. Nevertheless, for languages such as Nimboran, this is not a viable option; the phonological opposition in backness between /ɨ/ and /ɯ/ must be formally captured in some way in the lexicon. I thus conclude that the SPE feature system employing [±back] is not rich enough to deal with systems like this one and therefore must be rejected as being too weak. Clements (1991) and Kenstowicz (1994) make this same point as well.

The first major demonstration of the need to recognize a central vs. back distinction in the literature on vowel feature systems can be attributed to Clements (1991). He lists a number of languages which exhibit a phonemic opposition like that of Nimboran. I will briefly review his discussion here. A dialect of Swedish spoken in Finland has the three

high rounded vowels /y ʉ u/, where /y/ is front and /ʉ/ is central. Illustrative data include /dyr/ ‘expensive’, /bʉr/ ‘cage’, and /bur/ ‘lives’. Kiparsky (1974:170) comments, “In the Swedish of Finland, the contrast [y] : [ʉ] : [u] ... may well have to be considered as one of front : central : back. Unlike what seems to be the case in Sweden, there are no significant differences in lip rounding between the three vowels.” Inventories like that of Swedish (and others below), with a triple contrast, are of course especially interesting and compelling since they rule out the possibility that the vowel claimed to be central may actually be front or back instead.

Woleaian, an Austronesian language of the Trukic subfamily spoken in Micronesia, has the inventory /i e a o u ʉ/, where /ʉ/ is high central rounded. Furthermore, in its contrastively lengthened series Woleaian also contains the mid central rounded vowel /ɵ:/ in opposition with /o:/ (Sohn 1975:16-17).

Tsou, an Austronesian language spoken in Taiwan, also has the inventory /i e a o u ʉ/. Tung (1964) comments, “For the high central vowel, either of the two symbols ‘ɨ’ and ‘ʉ’ known in linguistic writings may be used. We choose the latter on the grounds that the average tongue position of the vowel is actually much nearer to /u/ than to /i/ and that it is in fact more or less rounded” (p. 19).

Further oppositions between central /ʉ/ and back /u/ are reported for a closely-related group of East Papuan languages spoken in the Solomon Islands. Representative inventories include the Malo dialect of Nambakaengö (also known as Santa Cruz or Löndäi): /i e ö æ a ə ʉ u o ɑ/ (Wurm 1972); the Nemboi or Menjembelo dialect of Nea: /i e ɛ ö a ə ʉ u o ɔ/ (Wurm 1972); the Nooli dialect of Nea: /i e ɛ ö æ a ə ʉ u o ɔ/ (Wurm 1972); Nelua: /i e ö a ə ʉ u o/ (Codrington 1885 and Wurm 1970); and Nanggu: /i e ö æ a ə ʉ u o ɔ/ (Wurm 1970 and 1972). All of these languages oppose central /ʉ/ and back /u/.

Clements’ final piece of evidence from phonemic inventories is provided by Nimboran (or Nambrong), a Trans-New Guinea Papuan language spoken in the Irian Jaya region of Indonesia (cf. §1). Anceaux (1965) describes its vowel system as consisting of /i e a ɤ ɨ ɯ/, where /ɤ/ is mid back unrounded. /ɨ/ and /ɯ/ are high central unrounded and high back unrounded, respectively. Furthermore, both of these vowels are reported to be “rather tense” and “close.” Minimal pairs include /ki/ ‘woman’, /kɨ/ ‘faeces’, and /kɯ/ ‘time; day’ (Anceaux 1965:13-15). Nimboran thus has the curious distinction of containing six vowels, all of which are [–round].

A further rich source for seeking phonemic contrasts of this nature is the UPSID inventory (Maddieson and Precoda 1992). In this genetically and areally balanced database surveying 451 languages, a number of additional cases emerge that Clements (1991) does not mention. Nevertheless, the frequency of such examples is exceedingly low, in keeping with the strong universal tendency that central and back vowels normally do not contrast if they are otherwise identical. For instance, 6 of the 451 languages in UPSID contain /ʉ/, while 369 contain /u/. Of these, 3 coincide in containing both /u/ and /ʉ/. Of 61 languages exhibiting an /ɨ/ and 41 exhibiting /ɯ/, only one language contains both. Of 392 languages containing /a/ and 22 containing /ɑ/, only 1 has both. Of 9 languages with /ɵ/ and 312 with /o/, 5 have both. Of 96 languages with /ə/ and 20 with /ɤ/, 2 have both. It would be a simple matter to demonstrate that several of these dependencies lead to a $\chi^2$ value which is statistically significant.[2] Nevertheless, since many of the expected values are less than five,

[2]The chi-square test is a statistical technique which evaluates whether there is a significant relationship between two variables. It does this by comparing the observed frequencies of the two variables with the frequencies that would be theoretically expected if they were not associated.

there is little point in carrying through on such an exercise. The total number of languages in UPSID which exhibit at least one minimal contrast between a central and a back vowel which are otherwise identical is nine. This amounts to 2% of the sample.

I now survey those UPSID languages which contain at least one contrastive pair of central vs. back vowels. In the following list I do not repeat languages already discussed by Clements (1991) and mentioned above. Furthermore, I only include here those cases which I have been able to confirm by accessing the original source(s), and I ignore secondary modifications such as phonemic nasalization, length, etc.

First, Khanty or Ostyak, a Ural-Altaic and Finno-Ugric language spoken in Russia, contains /i e æ a ɵ ʉ ɯ u o/. It thus contrasts central rounded /ʉ/ (high) and /ɵ/ (mid) with /u/ and /o/ respectively (Gulya 1966). This type of inventory is especially important since it contains three non-front high vowels (/ʉ u ɯ/). This rules out the possibility of attempting to explain away the opposition between /ʉ/ and /u/ as a difference in lip rounding. Thus even if /ʉ/ were claimed to be unrounded, it would still minimally contrast with /ɯ/ along the central-back dimension. Another case analogous to this is Komi (see below).

Bai, also known as Minkia or Minjia, is a Sino-Tibetan and Tibeto-Burman language of China. Its vowels are /i e ɛ a ɘ ɵ u ɯ o ɔ/. /ɘ/ is lower mid (lax) central rounded, and /ɵ/ is higher mid (tense) central rounded (Dell 1981).

Yukaghir or Tundra is a Ural-Altaic language of Russia.[3] Its phonemic vowels are /ɪ ɛ ạ ɵ o u/. /ɵ/ is mid central rounded and /ạ/ is low front unrounded (Krejnovich 1958 and 1968).

Moro or Dhimorong is a Niger-Congo and Kordofanian language of Sudan. It contains /i e a ə u o ɤ/. /ə/ is higher mid (tense) central unrounded and /ɤ/ is higher mid (tense) back unrounded (Black 1971; Schadeberg 1981).

Vanimo or Manimo is a Papuan and Sko language of Irian Jaya, Indonesia. The Dumo dialect has /i e ɛ a ɵ u o ɔ/. /ɵ/ is higher mid (tense) central rounded and thus contrasts minimally with /o/ (Ross 1980).

Axluxlay (also known as Ashushlay, Chulupe, and Nivaklé) is a Macro-Panoan and Mataco-Guaicuru language spoken in Argentina and Paraguay. It consists of /i e a ɑ o u/, where /a/ is low central lax unrounded and /ɑ/ is low back lax unrounded (Stell 1972).

Harms (1968) reports the following inventory for the Eastern Vyčegda dialect of Komi, a Uralic Finno-Ugric Permic language of Russia: /i e a ə ɨ ʉ u o ɵ/. /ʉ/ is high central rounded and /ɵ/ is mid central rounded.

Finally, Norwegian is reported to contrast three high rounded vowels which have the same lip position: /y/ (front), /ʉ/ (central), and /u/ (back). A minimal triplet is /by:/ ‘town’, /bʉ:/ ‘shack’, and /bu:/ ‘live’ (Vanvik 1972, Ladefoged and Maddieson 1996).

Another example, this one not in UPSID, is Bora, a Witotoan language spoken in Peru. According to Thiesen and Thiesen (1975), Bora’s inventory of vowel phonemes consists of /i e a o ɨ ɯ/, where /ɨ/ is high, central, lax, unrounded and /ɯ/ is high, back, lax, unrounded. These two segments thus differ in tenseness from the high front tense vowel /i/ in this language, a fact I have been able to confirm with acoustic measurements (Parker 2000).

[3]Grimes (1992) classifies Yukaghir as a linguistic isolate.

In Table 1 I summarize the above discussion by listing the languages known to minimally contrast central and back vowels. This list is exhaustive as far as I am aware, but given the fact that UPSID is a sample of less than 10% of the languages currently spoken in the world, undoubtedly there are more cases out there to be found:[4]

Because of an increasing number of reports in the literature of languages having contrasts such as those documented in Table 1 above, Ladefoged and Maddieson (1996:292) comment, "Consideration of a number of very different cases, such as Nweh and Norwegian, leads us to conclude that it is probably appropriate to recognize a front-back dimension containing three major phonetic categories: [front], [central] and [back]."[5]

I now shift from arguments based on contrasts to new ones based on dynamic phonological processes. That is, in addition to the evidence from phonemic inventories, it would strengthen our findings if we could also show that the central/back distinction in some of these languages is active in other areas of the phonology as well: morphophonemic alternations, redundancy rules, co-occurrence restrictions, etc.

The first piece of evidence of this type is provided by Clements (1991). In his discussion of the contrast between /ɨ/ and /ɯ/ in Nimboran, he notes that in certain morphological contexts /b/ is changed to [g] after the velar nasal /ŋ/ or /ɯ/. This assimilatory rule does not apply following /ɨ/ (Anceaux 1965). Here the argument is that the natural class which triggers this phonological process needs to group together /ŋ/ and /ɯ/ to the exclusion of /ɨ/. This can only be achieved if there is some feature which distinguishes between /ɨ/ and /ɯ/.

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[4]In Table 1 I use Nambakaengö as representative of the group which also includes Nemboi Nea, Nooli Nea, Nelua, and Nanggu. There are three additional languages claimed to have a central/back contrast, but the primary sources disconfirm the inventories listed in UPSID. Manchu, a Ural-Altaic Tungus language of China, is reported by Austin (1962) to distinguish mid central rounded /ɵ/ from /o/. However, many other detailed references to Manchu, such as Zhang (1996), do not even mention the vowel /ɵ/. Second, Temne, a Niger-Congo Kordofanian language spoken in Sierra Leone, is reported by UPSID to contrast low central unrounded /a/ and low back unrounded /ɑ/. However, both of UPSID's sources on Temne place the phoneme /ɑ/ in the mid central region of the vowel space (Dalby 1966; Wilson 1961). Finally, Woisika is a Trans-New Guinea Papuan language of Indonesia. UPSID reports it to also contrast low central unrounded /a/ and low back unrounded /ɑ/. However, Stokhof (1979), on which UPSID is based, contradicts UPSID's description on several points. In particular, he claims that /a/ and /ɑ/ differ in tenseness. Consequently, I do not consider this to be a canonical instance of a central vs. back contrast.

[5]For theoretical reasons related to the geometric representation of features, Selkirk (1993) claims that the primary source of distinction between vowels such as /ɨ/ and /ɯ/ is a lip gesture of inrounding (compression) for the latter. However, all the phonemic descriptions which I have referred to in this section were written by trained fieldworkers who have actually observed live native speakers of the respective languages for many years, and they unequivocably report such contrasts to involve backness, not lip function. Consequently, I doubt that Selkirk's presupposition is correct.

Table 1: Summary of central/back contrasts

| | central | back | |
|---|---|---|---|
| Finland Swedish | ʉ | u | high rounded |
| Norwegian | ʉ | u | high rounded |
| Tsou | ʉ | u | high rounded |
| Nambakaengö | ʉ | u | high rounded |
| Khanty | ʉ | u | high rounded |
| | ɵ | o | mid rounded |
| Komi | ʉ | u | high rounded |
| | ɵ | o | mid rounded |
| Woleaian | ʉ | u | high rounded |
| | ɵː | oː | long mid rounded |
| Nimboran | ɨ | ɯ | high tense unrounded |
| Bora | ɨ | ɯ | high lax unrounded |
| Vanimo | ɵ | o | mid tense rounded |
| Yukaghir | ɵ | o | mid rounded |
| Bai | ɵ | o | mid tense rounded |
| | ɞ | ɔ | mid lax rounded |
| Moro | ə | ɤ | mid tense unrounded |
| Axluxlay | a | ɑ | low lax unrounded |

Secondly, Woleaian contrasts /ʉ/ and /u/, as discussed above. In this language a word-final /i/ assimilates in backness when either of these two vowels precedes it. Sohn (1975) gives the following examples:

(2) a. /jalʉsʉli/ → [jalʉsʉlʉ̥] *ghost of*
b. /mengaaguli/→ [mengaagulu̥] *clothes of*
c. /gattʉi/ → [gattʉ] *my finger*

In the first two forms in (2) above the word-final harmonized vowels undergo an independent process of devoicing. This rule (devoicing) is blocked in long vowels and thus does not apply to /gattʉi/, in which the final vowel cluster is resolved by coalescence (or degemination) instead. The crucial detail here again is that the systematic opposition between /ʉ/ and /u/ in this language leads to a segmental alternation for which we need to distinguish between these two vowels in surface forms. This is additionally supported by the fact that the phoneme /m/ does not occur before /u/, while it does occur before all other vowels, including /ʉ/. What is more, Woleaian also contains an interesting co-occurrence restriction governing the concatenation of glides and vowels. According to Sohn (1975:35), /j/ does not appear before any high vowels, while /w/ is prohibited only before /ʉ/ and /u/ (that is, the sequence /wi/ does occur). These patterns further confirm the need to group central and back vowels as a class distinct from front vowels.

In conclusion, the unusual nature of Nimboran's vowel inventory is not an isolated phenomenon but rather exemplifies a larger tendency which is robustly attested cross-linguistically. Building on previous work by Clements (1991) and Maddieson and Precoda (1992), I have provided additional arguments of various types which force us to confront the implications of these facts for distinctive feature theory. As we have seen, there are several pieces of data which indicate that central and back vowels pattern together as a

phonological natural class: (1) harmonic suffixal allomorphy in Turkish; (2) a backing rule triggered by /ʉ/ and /u/ in Woleaian; and (3) the fact that /ɨ/ and /ɯ/ in Bora are lax while /i/ is tense. What unites all of these pairs is that they share the classical specification [+back] (or its equivalent). However, this feature cannot separate the members of each pair and so we must look for some other way to do that.

## 3. Previous approaches

In this section I survey earlier proposals in the literature for dealing with contrasts such as /ɨ/ vs. /ɯ/ in Nimboran. As I will demonstrate, each one has shortcomings. To summarize the empirical data from the preceding section, the important facts which any explanatorily-adequate theory must account for are the following: (1) a contrast between central and back vowels which are otherwise identical is very marked cross-linguistically; (2) central and back vowels are often grouped together as an exhaustive natural class; and (3) front plus central vowels never pattern together in this way (unless a feature other than backness is involved). Only the model which I propose in the next section is capable of encoding all of these details.

In the first place, we can immediately dismiss Lindau's (1978) proposal for a ternary specification of the feature [back]. In this system there is no straightforward way to group together central and back vowels to the exclusion of front ones. As we have seen, there is ample evidence for the existence of this natural class, yet a ternary-valued [back] feature cannot handle this dependency without additional formal machinery. Any such further stipulation would outweigh the potential benefits gained by the simplicity of an n-ary specification. Secondly, this maneuver is too powerful since there is no natural reason why an n-ary feature should be a priori limited to only three values, rather than four, or five. As Lindau herself notes, no language is known to distinguish more than three contrastive degrees of backness. In her approach this is an arbitrary, ad hoc coincidence. Furthermore, it would be unexplained why only [back] can be ternary in nature, while all of the other vowel features have just two values (an internal contradiction). The limitation of vowels to at most three series of backing falls out much more intuitively and directly if we capture such oppositions through the joint interaction of two maximally binary features, especially when these are independently motivated.[6] I thus conclude that Lindau's proposal is both too strong and too weak.

A second approach which has been suggested to distinguish between central and back vowels is the feature [±peripheral]. The insight here is that front rounded and central vowels fall more towards the middle of the articulatory space and thus are [–peripheral]. Conversely, front unrounded, back rounded, and low segments are [+peripheral]. Essentially equivalent usages of this feature are proposed by Stockwell (1966), Harms (1967, 1968), Lindau (1978), Ferrari (1984), and Labov (1994). Ferrari (1984) summarizes the relevant argumentation with the following discussion:

> It should be noted, however, that the high central vowels, although they occupy one of the margins of the phonetic space, do not fall within the peripheral category; this more restrictive definition of peripherality is justified on phonological grounds, as the high central vowels tend not to pattern with the true peripheral vowels in natural languages, and they are also less common than other peripheral vowels. Thus, high central

[6]Gnanadesikan (1997) argues for a relatively principled theory of ternary-valued features, but she does not extend her proposals to the feature [back].

> /ɨ/ and /ʉ/, along with the remaining phonetically centralized vowels, constitute the set of 'interior' vowels. (Ferrari 1984:139)

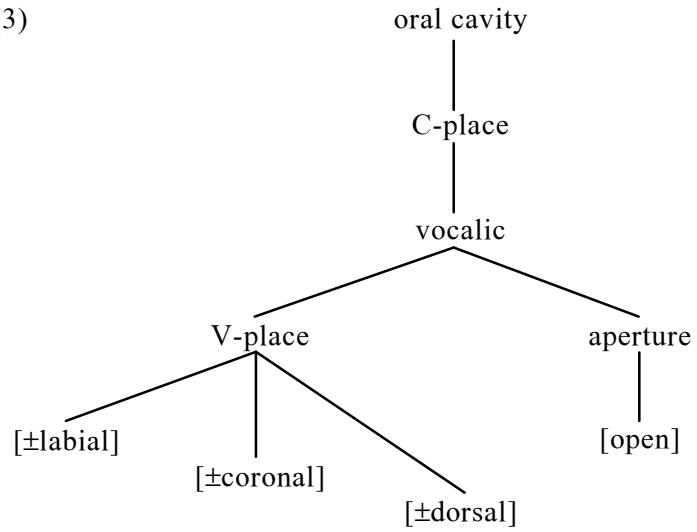
Nevertheless, I have three strong objections against the utilization of this feature for our purposes here. First, as Lindau (1978) acknowledges, there is a large overlap between [±peripheral] and the traditional feature [±ATR]. Lax vowels in general are articulated more towards the middle of the vowel space than their tense counterparts are. I thus conclude that these two features do basically the same work and hence are not independently needed (Lindau 1978). Therefore, for the sake of restricting our featural framework as much as possible, we should refrain from introducing [±peripheral] since there is strong cross-linguistic motivation for [±ATR] to perform a nearly identical function.

Secondly, it is doubtful that the natural classes which this feature predicts to exist and not to exist are empirically supported. For example, the specification [–peripheral] could group together front rounded vowels and central (unrounded) vowels to the exclusion of back (rounded) vowels in languages like Turkish (cf. §2). However, no evidence has been presented to indicate that such a grouping is necessary for any attested phonological phenomenon.

Finally, even if we did allow for a feature such as [peripheral], it is unlikely that this could be the relevant contrast for vowels like /ɨ/ and /ɯ/ in Nimboran. The reason is that acoustic measurements of the vowel /ɯ/ in five different languages indicate that /ɯ/ is a strongly centralized, interior vowel and thus should be specified as [–peripheral] (Ferrari 1984; Papçun 1976; Parker 2000). Furthermore, we have seen that /ɨ/ is also non-peripheral, in the quote from Ferrari (1984) above (she also categorizes the segments /y ø ɵ ʌ ɤ/ as interior ([–peripheral]) as well). The problem is that proponents of this peripherality distinction have apparently not taken into account the contrast between central and back *unrounded* vowels. Therefore, the proposed feature [±peripheral] would be incapable of encoding the phonemic opposition between vowels like /ɨ/ and /ɯ/ and thus must be rejected as a solution to the problem at hand.

To date the most successful model for distinguishing between central and back vowels is a system espoused by Clements (1991) and Clements and Hume (1995). In this approach there are two basic assumptions which will be relevant for later discussion, so I will briefly review them here. First, Clements and Hume posit separate yet parallel place features for consonants and vowels. Their consonantal place features [labial], [coronal], and [dorsal] are privative, while the corresponding vowel features are binary. (For conciseness I will henceforth refer to this approach as the *Binary Place Model* or *BPM*.) Furthermore, the vowel place features group together under a vocalic node which is in turn subordinated to a consonantal place node. The relevant section of their feature geometry tree therefore has the following structure (Clements and Hume 1995:292):

(3)




One of the principal motivations for a separate vocalic node dominated by C-place is the fact that vowel place features spread much more freely than consonantal place features do. Thus in many languages processes of total vowel harmony are not blocked by intervening consonants (regardless of their point of articulation), whereas place assimilation between consonants is nearly always limited to segments which are adjacent and therefore not split by vowels (cf. Gafos 1998). In the more traditional geometric models of Sagey (1986) and Halle (1995), where vowel place features are dominated by a Dorsal Node, an incorrect prediction is made concerning this phenomenon: only velar consonants (and perhaps underspecified coronals) should allow vowel place to freely spread across them, whereas consonants at other points of articulation should always be opaque. However, processes of complete vowel harmony in languages such as Kolami (Emeneau 1955) and Klamath (Odden 1991) show that this is not the case (Clements 1991, Kenstowicz 1994, Clements and Hume 1995). Therefore a segregation between vocalic and consonantal place features captures such generalizations more naturally than other proposals do.

A second crucial assumption of the Binary Place Model is that front vowels are specified as [+coronal]. Phonetic evidence for this innovation is provided by Hume (1992), who cites x-ray data from several languages indicating that the articulation of front vowels involves a raising of the front of the tongue (Kenstowicz 1994). This is confirmed by phonological evidence from natural class patterns in which front vowels group together with coronal consonants. For example, in Maltese Arabic, vowels are fronted next to coronal consonants (Hume 1991), and in Kirundi certain consonants are "coronalized" before front vowels via a process of palatalization (Broselow and Niyondagara 1990). If both of these groups of segments share a coronal specification, rules of this type can easily be seen as assimilatory in nature. However, if front vowels are considered to be [–back] Dorsal segments à la Sagey (1986), these changes are arbitrary. In Sagey's model dorsal consonants form a natural class with all vowels. This wrongly predicts that velar and uvular consonants should block harmony processes spreading the feature [±back] (Clements and Hume 1995). Another argument is provided by the existence of a tautosyllabic co-occurrence requirement between front vowels and coronal consonants in Cantonese (Cheng 1989, Kenstowicz 1994, Clements and Hume 1995). All of these facts support the move to phonologically categorize front vowels as [coronal].

An additional advantage of the BPM is that by introducing [coronal] as a vocalic feature and positing a binary [±dorsal] split, we derive the side benefit of being able to capture the three-way opposition in backness for vowel systems like that of Nimboran. In this approach we have the following specifications:

(4)

| | y | ʉ | u |
|---|---|---|---|
| +labial | | | |
| –labial | i | ɨ | ɯ |
| coronal | + | – | – |
| dorsal | – | – | + |

Front vowels are now distinguished as [+coronal], central vowels are [–coronal, –dorsal], and phonetically back vowels are [+dorsal].[7] As Clements (1991) and Kenstowicz (1994) point out, in this approach the traditional feature [±back] (as well as [±round]) becomes superfluous and hence can be eliminated from the universal feature inventory, simplifying the theory.

However, this maneuver does not come without cost: in another important realm it entails a concomitant increase in expressive power. In order for the BPM to work correctly, we must assume that the vocalic place features are binary, as noted above. Otherwise, we could not distinguish between central and back vowels. Nevertheless, by allowing for negative values of features such as [labial], [coronal], and [dorsal], this approach introduces a number of problems as well. A major concern here is of course the issue of monovalency: in nearly all other competing models of feature geometry, place features such as coronal and dorsal are claimed to be privative class nodes (Sagey 1986, McCarthy 1988, Halle 1995, Steriade 1995, etc.). Lombardi (1996) notes that there is nearly universal agreement on this point. She demonstrates that negative values for [labial] and [coronal] are needed only postlexically. In the earlier (lexical) levels of the phonology, she claims, place features are indeed privative. This is in keeping with a large body of work since 1986 confirming the Sageyian model. For example, as Kenstowicz (1994) notes, there are no compelling facts requiring equipollent values like [–dorsal] and [–radical] for place of articulation features. Lombardi (1991) similarly finds no evidence for [–dorsal]. An inherent drawback of negatively-valued place features such as [–dorsal] is that this specification allows us to group together labial, coronal, and pharyngeal segments as a false natural class for which there is no real motivation. Rather, Kenstowicz (1994) reiterates the point that for consonants, [coronal] and [dorsal] need to be monovalent in order to account for details such as the well-known Arabic root co-occurrence constraints (driven by the OCP on place tiers). Therefore, in the Binary Place Model, the proposal to make vowel place features binary while their consonantal counterparts are privative constitutes an internal inconsistency which its own proponents acknowledge to be problematic (Clements 1991, p. 80, p. 115, and fn. 1; Clements and Hume 1995, pp. 252, 289-91). I thus conclude that there are strong a priori reasons for preferring a model of feature geometry in which the traditional articulator nodes Coronal and Dorsal remain monovalent.

Considering now the implications of the BPM more specifically for languages which contrast central and back vowels, we will come to a similar conclusion. As I noted earlier, the classical feature [±back] directly encodes the fact that central and back vowels often form a natural class to the exclusion of front vowels. After this initial split is made, it sometimes then becomes necessary to distinguish between central and back vowels within

[7]Wang (1968) proposes a virtually equivalent system in which vowels like /ɨ/ and /ʉ/ are [–palatal, –velar].

this non-front class. In the BPM system, this strong statistical dependency is lost since central and back vowels are no more closely related than front and central vowels are. In this model we can group together vowels like /ɨ/ and /ɯ/ with the feature [–coronal], but we can just as easily isolate /i/ and /ɨ/ to the exclusion of /ɯ/ as the class of [–dorsal] vowels. In this approach no special status is given to the equivalent of the classical feature [±back]. If we could somehow distinguish between central and back vowels while retaining this natural insight of the SPE tradition, we would improve on the Binary Place Model.

The reason why this is an important issue is because no language is known to group front and central vowels vs. back vowels which are otherwise identical. That is, given a three-way contrast such as that between /y ʉ u/ in Norwegian, there is no evidence that any phonological process or constraint would ever target /y/ and /ʉ/ exclusively to undergo or trigger any rule without also including /u/. Of course, if another contrastive feature such as round or tense were introduced, producing for example a slightly different system containing /i ɨ u/, it would be possible to isolate /i/ and /ɨ/ as the class of vowels which are [+high, –round]. I do not deny that such groupings are attested and therefore necessary. What I do want to rule out, however, is the usage of the feature [–dorsal] to generate a class of this type since no such cases seem to exist. As an illustration, recall the inventory of high vowels in Bora: /i ɨ ɯ/, where /i/ is tense and /ɨ ɯ/ are lax. For this system we need to write the following redundancy rule, using the classical definition of the relevant features:[8]

(5) $\begin{bmatrix} +\text{high} \\ +\text{back} \end{bmatrix} \rightarrow$ [–tense]

It would be a straightforward matter to translate this into the BPM equivalent:[9]

(6) $\begin{bmatrix} -\text{open} \\ -\text{coronal} \end{bmatrix} \rightarrow$ [–tense]

However, imagine now a hypothetical language which had the mirror-image of Bora's inventory of high vowels: /ɪ ɨ ɯ/, where /ɪ/ and /ɨ/ are both lax but /ɯ/ is tense. A systematic inspection of all 451 languages in the UPSID database failed to reveal a single case of this type, either among high vowels or non-high vowels. Furthermore, I am not aware of any facts from rules or constraints which motivate such a grouping.[10]

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[8]Regardless of whether the feature which best characterizes the laxness of /ɨ/ and /ɯ/ in Bora is [–tense], [–ATR], or [–peripheral], the fact remains that these two vowels are closer to the center of the vowel space than /i/ is and thus group together as a phonological natural class (Parker 2000).

[9]In the formalization of rule (6) I employ [–open] as the equivalent of [+high] in the BPM approach. This is only for the sake of consistency within that model; nothing in this paper crucially hinges around the question of how vowel height is best encoded in our formal theory of distinctive features.

[10]One possible exception to this claim has come to my attention, but it is not at all transparent. UPSID lists the following inventory for Bashkir, a Ural-Altaic Turkic language of Russia: /i ø æ ʉ ə ʊ o ɤ ɑ/. Poppe (1964) reports that Bashkir exhibits a constraint of palatal harmony by which all vowels within a word must be either front or back. The front series consists of /i ə æ ʉ ø/, and the back series is /u o ɑ ɤ/. However, Poppe's description of the phonetic quality of these vowels is highly confusing. He categorizes /u/ as "close" but like the vowel in *book*. Furthermore, he calls /ə/ "front" and /ʉ/ "centralized" and "front." He also transcribes /ʉ/ as [ɯ] and /ü/. He lists both /ö/ and [ɵ] as alternates for /ø/, which he also describes as "front" and "centralized". He uses the symbol [ɵ] for /o/ as well, and further transcribes /ɤ/ as /ï/. Given this ambiguous and contradictory state of affairs, nothing definite can be concluded about this process until the facts are clarified.

Nevertheless, the BPM proposal predicts that such classes should exist since they could very easily be captured by the counterpart of redundancy rule (6) above:

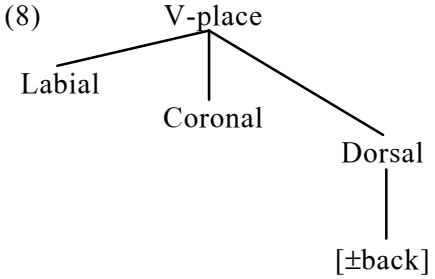
(7) $\begin{bmatrix} -\text{open} \\ -\text{dorsal} \end{bmatrix} \rightarrow [-\text{tense}]$

In an approach relying on binary-valued vowel features such as [±coronal] and [±dorsal], it is a simple matter to describe a class consisting of just front and central vowels. The fact that no such cases exist is a problem for the BPM since it overgenerates the potential for categorizing natural classes. A more constrained system which a priori prevented this situation from arising would therefore constitute a significant improvement over a theory employing the equipollent feature [±dorsal]. One of the goals of Universal Grammar is to organize feature geometry trees in such a way that they are limited to capturing all and only those natural classes of segments which are actually attested in human languages. I therefore conclude that the BPM proposal is too strong since it introduces undesirable power into phonological theory and hence is not the optimal solution. Kenstowicz (1994:465) echoes this sentiment with the following remark: "These facts indicate that the replacement of [±back] with [coronal] and [dorsal] is not entirely successful."

## 4. A new proposal

In this section I propose a slightly modified version of the BPM system which remedies the shortcomings of this model, as discussed above. In my approach I retain the basic distinction between the C-place and V-place tiers, and I furthermore consider the coronal specification of front vowels to be correct. Where I differ from the BPM is in positing that the vocalic place of articulation features [labial], [coronal], and [dorsal] are privative class nodes, as in other versions of the theory. What is more, a second crucial modification is that I retain the feature [±back]. However, this binary feature is stipulated to be a dependent of the Dorsal Node only, and it is redefined so as to capture the distinction between central and back vowels.[11] Starting from the BPM tree, my revised V-place node thus has the following structure (cf. (3) above):

(8)




Central vowels are now defined as [–back] (under the Dorsal Node) while phonetically back vowels are [+back]. The feature [±back] is not relevant for front vowels, which have a Coronal Node only. This redefinition of the feature [±back] is independently justifiable on other phonological grounds as well. In the SPE model the feature [back] is defined in relation to a neutral position corresponding to the vowel /ɛ/ (cf. §2). Claiming that /ɛ/ is the universally neutral vowel is an artifice of that feature system (SPE) which has never

[11]The classical features [anterior] and [distributed] have likewise been reassigned as a daughter of the Coronal Node in many models of feature geometry (Sagey 1986, Steriade 1986, McCarthy 1988, Kenstowicz 1994, etc.). The crucial difference between my approach and the BPM is that for me, Labial, Coronal, and Dorsal are monovalent nodes, even though they have binary terminal features hanging off of them.

been confirmed by any evidence from actually attested phonological rules or constraints. Rather, a number of facts indicate that the truly "neutral" vowel in terms of cross-linguistic phonological patterning is /ə/. Thus, for example, in languages which exhibit a systematic process of vowel reduction (such as English), the output segment is typically [ə]. Similarly, Oostendorp (1995) argues extensively that [ə] is the empty or neutral vowel in Dutch, French, and Norwegian. Furthermore, in those languages which have only one contrastive vowel series in terms of backness, all vowels are invariably central (Lindau 1978:547; see also Trubetzkoy 1962 and Hockett 1955). For example, in Adyghe, a North Caucasian Circassian language of Russia, the only phonemic vowel is /a/ (and possibly /ə/: Kuipers 1960). Similarly, the North Caucasian language Abkhaz of Georgia and Turkey has only /a/ and perhaps /ə/ (Hewitt 1979). And Ubykh or Oubykh, another related language of Turkey, has only /a a: ə/ (Vogt 1963).[12] Hockett (1955) and Trubetzkoy (1962) analyze these languages as having /ɨ/ as well. Even if this were not true, the fact remains that all languages have at least one central vowel, whereas not all languages have front and/or back vowels. This is further justification for defining the neutral vowel position as corresponding to the segment /ə/, not /ɛ/. This clearly makes sense in terms of the physical geometry of the articulatory vowel space as well since /ə/ occupies the most central position. For reasons such as these, most of the phonologists who analyze vowels in terms of monovalent gestures or particles assume that /ə/ (or /ɨ/) is the maximally unspecified vowel (Schane 1984, Anderson and Ewen 1987, Alderete 1995, Zubritskaya 1995, Kager 1999). It is thus a very natural and logical move to redefine the feature [±back] in terms of a retraction of the tongue body away from the position of the neutral vowel /ə/. In my proposed system we can now employ the following specifications to distinguish vowel inventories like that of Nimboran:

(9)

| | i | ɨ | ɯ |
|---|---|---|---|
| Coronal Node | • | | |
| Dorsal Node | | • | • |
| [back] | | – | + |

The feature [±back] is now defined as follows: [+back] sounds are Dorsal segments articulated by retracting the body of the tongue (the palatine dorsum) from the neutral position; [–back] sounds are Dorsal segments articulated without such a retraction from the neutral position (cf. Chomsky and Halle 1968). In this definition the "neutral position" is to be understood as a tongue and jaw configuration approximating that of the vowel /ə/. The physiological gesture which provides an anatomical basis for this characterization of dorsal backing is contraction of the anterior fibers of the geniohyoglossus muscle (Zemlin 1998).

This model of distinctive feature organization improves on several of the shortcomings inherent in the BPM proposal and consequently has many advantages compared to that system. Recall that in that approach the need for a three-way distinction in backness is resolved through an interaction between the two binary features [±coronal] and [±dorsal]. This is parallel to the classical model which derives three vowel heights by positing the two features [±high] and [±low]. However, several factors indicate that these two axes (height and backness) do not behave in symmetrical ways: (1) whereas high and mid vowels, categorized by [–low], and mid plus low vowels ([–high]) often pattern together as natural classes, there is no compelling need for the corresponding backness features

[12]Other languages analyzed as having a "vertical" (central) vowel series with only one contrastive degree of backness are Marshallese (Bender 1968; Choi 1995) and Margi (Maddieson 1987).

[–coronal] and [–dorsal]. In my system these negative specifications are a priori ruled out by positing monovalent class nodes. This revision makes the V-place features entirely equivalent to their consonantal counterparts, increasing the consistency of the Binary Place Model. (2) There is a strongly attested preference for grouping central and back vowels to the exclusion of front ones. Furthermore, central and back vowels rarely contrast. This asymmetry is directly encoded in my formal proposal by making two splits along the backness dimension. First the Coronal Node (front vowels) is separated from the Dorsal Node (non-front vowels). Subsequently a contrast is made possible under the Dorsal Node by the more localized feature [±back]. By placing this feature at a lower position in the tree than the Coronal Node, the cross-linguistic asymmetry in natural class patternings is directly mirrored by being hard-wired into the structure of Universal Grammar. (3) In my approach it is impossible to group together front and central vowels to the exclusion of back vowels which are otherwise identical. Unless they are distinguished from back vowels by rounding, height, and/or tenseness, front and central vowels never form exhaustive natural classes in any known human language. My more restrictive theory hence automatically avoids an unattested pattern which in the BPM approach is a glaring accidental gap. I thus conclude that my proposed system captures all the relevant facts in a more logical and natural way than various alternatives which have been previously espoused.

Before closing this section, I need to show that in my approach we can handle all the facts which have been previously accounted for with the feature [±back] as it was classically defined. In the geometry which I propose in (8) above, there is no direct "communication" possible between front vowels (under the Coronal Node) and the revised feature [±back] (under the Dorsal Node). This naturally raises the question of how to deal with processes that require us to simultaneously manipulate both values of the traditional feature [back]. For example, Kenstowicz (1994) notes the potential problem for the BPM (and by analogy my model as well) in explaining vowel harmony systems which appear to spread [αback]. However, given the insight of underspecification theory that default feature values are often filled in postlexically, Clements and Hume (1995:290) note that the evidence for the classical feature [–back] is "far from overwhelming." Furthermore, in anticipation of this objection they point out that we can now simply posit two spreading processes (if in fact both are necessary): one targets the Coronal Node and the other the Dorsal Node. Given the fact that the plus and minus values of any particular feature very rarely spread under exactly the same conditions anyway, this is not that great a complication. Nevertheless, we must still deal with the fact that in the classical autosegmental account of Turkish harmony, specification for [αback] blocks the spreading of [–αback] (Kenstowicz 1994). In their response to this issue, Clements and Hume (1995) suggest that we can rely on a proposal by Browman and Goldstein (1989) for a Lingual Node dominating Coronal and Dorsal.[13] Under this assumption, all of the facts of Turkish vowel harmony can be adequately accounted for by simply spreading the entire Lingual Node. Opaque segments block this propagation by being specified for a contrary value (the Coronal or Dorsal Node) on the Lingual tier.

As pointed out by Browman and Goldstein (1989) and Clements and Hume (1995), there is some independent motivation for a lingual node apart from just this usage. For example, one part of the tongue (front/tip or back/body) cannot move completely independently of the other part. The entire tongue therefore constitutes a single articulatory unit separate from the lips and pharynx. A privative Lingual Node can therefore allow us

[13]Browman and Goldstein (1989) refer to this simply as the Tongue Node.

to do away with the need for the infelicitious feature [–labial] in cases such as Mandarin Chinese (Clements 1976). Furthermore, laterals in the Kuman language of Papua New Guinea (Lynch 1983) alternate between alveolar and velar, but always involve some part of the tongue, just as they do in English. I thus assume that a proposal along these lines offers hope for a system like mine which no longer employs the classical feature [–back] for front vowels and certain palatal(ized) consonants. I refer the reader to Clements and Hume (1995:289-91) for a more detailed and adequate treatment of this issue.

## 5. Conclusion

To summarize the findings of this paper, two major themes have dominated the discussion. First, central and back vowels which agree in height, rounding, and tenseness almost never contrast in any given language, although in rare cases they do. Second, central and back vowels often pattern together in ways that front plus central vowels never do. The strong convergence of these two tendencies is undoubtedly not accidental. Rather, the physical force which naturally inhibits a central/back contrast to begin with (a minimal $F_2$ distinction) also serves to group these segments together when both types do in fact co-occur. Previous evidence for a contrast between central and back vowels has been limited primarily to phonemic inventories of high vowels. In this study I have provided further confirmation for the two premises above from several more domains: (1) phonemic contrasts in backness among mid and low vowels; (2) inputs, outputs, and triggers of productive phonological processes; (3) redundancy rules; and (4) co-occurrence constraints.

I have also considered the implications of these facts for distinctive feature theory. In conjunction with this goal I have proposed a new model of feature organization which accounts for the data better than previous approaches. Although I have retained the traditional binary feature [±back] (albeit with a slightly revised definition), this is amply compensated for by avoiding the dubious equipollent values of the standard place of articulation features. Furthermore, my system makes more restrictive predictions concerning which natural classes can and cannot occur, a detail which is confirmed by the empirical data. A beneficial side effect of my account is that it also entails a more adequate characterization of the neutral vowel position, a refinement which is independently motivated in any case. Finally, I have been able to achieve all of these improvements without introducing any new formal devices that would expand the power of phonological theory, and therefore my model is consistent with the traditional assumptions of well-established and widely-accepted feature geometry mechanisms.

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